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THE ROLE OF INFRASTRUCTURE IN
PAKISTAN'S ECONOMIC DEVELOPMENT, 1972-1991.

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Introduction

For most of the 1980s, the Pakistan economy performed well, with Gross Domestic Product (GDP) increasing by over 6 per cent per annum. However, the latter part of the decade was characterized by increasing fiscal and external deficits, infrastructure deficiencies and disruptions in production. In 1989 the Government initiated a three-year structural adjustment program with the assistance of the International Monetary Fund (IMF). The program sought to redress the growing macro-imbalances, resulting from large fiscal deficits, and to increase productivity through major structural reforms in the real as well as the financial sectors.[1]

By the late 1980s fiscal imbalances resulted in the public sector's gross fixed investment declining in real terms in both 1988 and 1990. In fact a relative decline in the growth in public sector investment occurred throughout the 1980s, so that by the end of the 1980s the growth in capital formation was the lowest in the country's history.[2] The limited expansion of public sector investment is particularly disturbing in lieu of sbasethe fact that the country's stock of infrastructure is modest even by third world standards. Clearly, if a stable relationship exists between increases in social overhead capital and private sector capital formation

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then the likely declines in public investment stemming from current austerity programs may have severe consequences for the nation's development process.

The purpose of this paper is to examine the consequences of declining public sector investment in Pakistan. Specifically, we are interested in examining the impact on the economy of these trends in infrastructural investment. Has investment in this area acted primarily to increase output or has it stimulated private sector investment? Alternatively, has public infrastructure been passive, largely responding to obvious needs created by growth of private sector capital formation?

Patterns of Investment and Infrastructural Development

The Pakistan Government does not publish data on the stock of and increments to the country's infrastructure. However, Blejer and Khan suggest two approaches to approximate increments to the nation's infrastructural base.[3] The basic assumption underlying these proxies is that infrastructure investment is an ongoing process that moves slowly over time and cannot be changed very rapidly.

The first approach takes the trend level of real public sector investment as representing the long-term or infrastructural component. In the discussion that follows this measure is referred to as "estimated infrastructure." In computing this measure of infrastructure we have used a linear trend (see note to Table 1). Deviations of real public sector investment from the trend are assumed to correspond to non-infrastructural investment.

A second approach is to make the distinction between types of public investment on the basis of whether the investment is *expected* or not. Again, it is assumed that expected, or *anticipated,* public investment is' closer to the long-term or infrastructural component. If deterioration is occurring in the country's stock of infrastructure, this measure may be a more accurate proxy than that obtained using the trend method.

The data reveal several trends in' the pattern of public sector investment (See Table 1). First, there has been a gradual deceleration in the rate of increase in the government's gross capital formation. For the period as a whole, real public capital formation increased at a rate of 8.3 per cent per annum. However, the data reveal two distinct periods: during

the 1970s, the real rate of public capita formation was 14.5 per cent, sharply declining to 3.7 per cent per annum during the 1980s. Nevertheless, it should be noted that public sector investment increased to a rate of 5.6 per cent during the 1985-90 period.

Second, in terms of the composition of public sector capital formation, investment in the energy sector had the fastest rate of expansion, averaging 13.3 per cent over the 1973-90 period, accelerating to 18.3 per cent in the 1980s.

Third, public enterprises experienced the lowest overall rate of capital formation, averaging 6.4 per cent per annum for the entire period. These enterprises include the railway and the post office, telegraph and telephone departments.

Fourth, non-energy semi-public organizations showed the sharpest decline in investment in the 1980s, averaging 6.2 per cent rate of growth in the 1980s (compared to 16.9 per cent in the 1970s). More importantly, capital formation in this area *contracted* at an annual rate of 4.8 per cent during the 1985-90 period.

General government capital formation in Pakistan consists of investment undertaken by the federal, provincial and local governments. These agencies account for around 30-40 per cent of total public investment, averaging 36.6 per cent during the 1980s.[4] A pattern similar to total public sector investment exists in that general government investment averaged slightly less than that experienced by the public sector as a whole, averaging 13.1 per cent (versus 14.5 per cent for total government) for the entire period under consideration. This decelerated to 7.8 per cent in the 1980s (versus 3.7 per cent for total government). As the data indicate, provincial government investment expanded the most rapidly over the 1972-90 period, followed by federal and local government capital formation. In the 1980s however there was a shift to local investment with rates of investment averaging 9.6 per cent per annum for local government (and 14.4 per cent for the 1985-90 period) compared to 8.5 per cent for provincial governments (and provincial government capital formation at 5.6 per cent for the 1985-90 period).

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TABLE 1
PAKISTAN: GROWTH RATES OF PUBLIC SECTOR INVESTMENT IN
INFRASTRUCTURE, 1973-1990

Sector	Percentage Growth Rates by Period			
	1973-90	1973-80	1980-90	1985-90
Energy	13.3	9.1	18.3	18.2
Public Enterprise	6.4	7.1	6.0	1.2
Semi-Public Organizations[a]	3.3	16.9	6.2	-4.8
Total Government	8.3	14.5	3.7	5.6
Level of Government				
Total General Government	10.1	13.1	7.8	6.9
Federal Government	9.5	14.0	6.1	5.1
Provincial Government	11.6	15.6	8.5	5.6
Local Government	7.6	5.2	9.6	14.4
Estimated Public Investment[b]				
Energy	7.5	10.4	5.5	--
Public Enterprise	6.5	8.5	5.2	--
Semi-Public Organizations[a]	2.7	3.0	2.5	--
Total Government	6.3	8.4	4.8	--
Estimated Public Investment by **Level of Government[b]**				
Total General Government	7.5	10.4	5.5	--
Federal Government	6.5	8.8	5.0	--
Provincial Government	8.3	12.0	5.8	--
Local Government	9.4	14.0	6.3	--
Expected Public Investment[c]				
Energy	13.6	14.1	13.2	22.5
Public Enterprise	4.6	4.5	4.7	0.7
Semi-Public Organizations[a]	2.9	9.3	-1.3	-0.9
Total Government	7.3	11.7	4.3	6.8
Expected Public Investment **by Level of Government[c]**				
Total General Government	8.7	12.7	5.9	6.6
Federal Government	7.0	10.7	4.5	7.0
Provincial Government	9.4	14.7	5.9	5.0
Local Government	7.6	1.1	12.4	10.1

Source: Compiled from data in World Bank, *Pakistan: Current Economic Situation and Prospects--Report No. 9283-PAK* (March 22, 1991); and World Bank, *Pakistan: Progress Under the Sixth Plan* (1984).

Notes: a = non energy public organizations; b = Infrastructure estimated from equation $Y_t = a + TIME_t$ where Y_t is public sector investment in year t and TIMEt is a time trend. Infrastructure is the predicted value of Y_{tc} = Expected infrastructure estimated from equation $Y_t = a + Y_{t-1}$ where Y_t is public investment in year t and Y_{t-1} is the same investment lagged one year. Infrastructure is the estimated value of Y_t.

As a result of these patterns, the share of the federal government in general government capital formation has fallen from around 38-40 per cent in the early 1980s to 32-34 per cent by the late 1980s. Provincial governments have maintained a fairly constant share at around 48-50 per cent, while local governments have seen their share of general government capital formation increase from 12-15 per cent in the late 1970s-early 1980s to nearly 20 per cent by 1990.[5]

As one would expect, these patterns have been mirrored in the case of estimated and expected public sector investment in infrastructure. (See Table 1).

The Role of Infrastructure in Development

The patterns of infrastructure investment noted above are important largely because of their implications for medium and longer term economic growth, both at the national and regional levels. The potential of infrastructure to affect movements in income has long intrigued economists. This possibility is clearly suggested by infrastructure's key role in Hirschman's unbalanced development strategy and in the theory of inter regional comparative advantage.[6] If a stable relationship between infrastructure and growth exists, Pakistan's public sector would have a powerful tool to stimulate national economic development.

Unfortunately there is no consensus on this issue. Instead, there is a broad spectrum of viewpoints concerning the role of infrastructure in the development process. There is a consensus, however, on the need for basic infrastructural facilities in potential development areas. Transport, for example, can be a limiting factor without which no development process could take off even if other development inducing factors were in play. Beyond this point, opinions on infrastructure's role in socioeconomic development processes differ widely.

In the case of transport, some transport economists take the view that the role of transport is simply to "relieve tensions" generated by supply and demand patterns as well as potentials scattered throughout the region.[7] In their view, transport has merely a derived function. In support of the argument that transport investment merely spreads growth rather than inducing growth, these experts claim that regional growth following alterations in the transport system is simply the result of

processes having been geographically displaced which would have occurred in any case in another place. Transport is thus unable to induce independent development processes, and socioeconomic disparities in the region are the cause and not the result of the region's inadequate transport system. In the opinion of these experts, the stimulus that railways (as the first efficient mode of transport) gave to industrial growth is grossly overestimated. According to them, the take-off in the oldest industrial countries occurred before the advent of the railway and is attributable to numerous and far more complex determining factors.

One small group of transport economists, led by Fritz Voigt, maintain that alterations in the transport system exert a follow-on influence on macroeconomic and social processes.[8] Their main contention is that autonomous or induced changes in the transport system produce external effects on the area serviced. Because of the space-bridging function of transport, these external effects have such a strong impact that a differentiation of development opportunities sets in, varying in extent according to the scale of the transport measures taken. Under certain conditions the impulses generated by efficient transport facilities not only induce socioeconomic development processes but also constitute a decisive independent variable of regional disparities in prosperity levels. Thus, according to this perspective, the tempo of development processes in a market economy is determined by the technological level of transport.

Hirschman's unbalanced growth strategy is a variant of this position.[9] In Hirschman's view, a rapid expansion in infrastructure unbalances an economy. In doing so, infrastructure not only creates a wide spectrum of newly profitable areas of investment for the private sector. Perhaps even more importantly, areas become more easily identified by inexperienced investors. In short, over significant intervals of time, developing countries pursuing Hirschman's unbalanced growth strategy should experience sustained and perhaps even abnormally high rates of private sector investment. This outcome stems directly from the incentives and pressures associated with the relative expansion of the stock of social overhead capital.

The majority of transport economists take a middle position between these two more or less diametrically opposed views. Some consider the transport system to be a function of the level of socioeconomic development. In other words, the more economically and socially backward a potential development region, the stronger will be the impulses emanating from improvements in the transport system. Others feel that the reciprocal relationship between changes in the transport system and socioeconomic development is such that the problem of cause and effect is not open to solution. This applies also to the large number of interdependencies that remain to be tested empirically.

The fundamental importance of the relationship between changes in the stock of infrastructure and the pattern of socio-economic development has led to considerable research activity. However, most of this research has focused on the role of transportation in alleviating regional disparities in the more developed countries.[10] In addition, and almost without exception, the case studies published to date have been undertaken without any general theory as a basis, and have produced no tenable theories of their own.[11] Commenting on the state of transportation economics, Alder has noted that "it is frequently assumed that all transport improvements stimulated economic development. The sad truth is that some do, some do not and that there may be better investment opportunities."[12]

Clearly, much of this debate centers on the issue of causation: does infrastructure cause growth or does investment of this type simply respond to the needs created by such growth? Empirical studies have largely simply assumed, rather than verifying, the direction of causation. For example, Glover and Simon argue that higher population density in developing countries has made a significant contribution to road building.[13] Simon contends that a positive effect stems from the impact of population density on agricultural savings in irrigation systems.[14] Both studies included per capita income as well as population density as an independent variable. In the Glover and Simon study, per capita income was found to have a significant and positive effect on road building, but in Simon's paper its effect on irrigation systems was negligible. In a later study, Frederiksen confirmed the cross sectional analysis of Glover and Simon with a case study of the Philippines.[15] However, it should be noted that these studies simply assumed the linkage was from population to infrastructure and thus they placed infrastructure on the right hand side of

the equation. Similar statistical results would of course be found if infrastructure had been assumed to be the independent variable.

Clearly, for policy purposes one needs to know the direction and magnitude of causation between infrastructure and the economy. If infrastructure leads and stimulates the economy then it is a valuable policy variable for such programs as attacking regional income disparities. In this circumstance, however, capital facilities are likely to be underutilized and their benefits spread out over a considerable time period. On the other hand, if infrastructure is more passive, simply responding to the pressures placed on existing facilities, then it acts more as a bottleneck. Under these circumstances the productivity of expanded infrastructure facilities may be quite high and its contribution to the economy realized rather quickly.

Linkages between infrastructure and the economy are difficult if not impossible to sort out through simply examining the historical record. In the case of Pakistan, several patterns seem to stand out. First, for the period as a whole, public investment has gradually expanded its share of total capital formation from 38.8 per cent in 1972 to 48.7 per cent in 1990. Correspondingly the share of private investment declined from 61.2 per cent to 51.3 per cent.[16] As a result, the 1970s were generally a period of increasing infrastructure per unit of private investment, with the 1980s a period of decreased support for private investment--increasing rations of private investment to infrastructure. The one exception is in the energy sector where rapid rates of public sector investment have resulted in a dramatic fall in the amount of private sector investment per increase in energy infrastructure.[17]

As Table 2 indicates, while the overall ratio of investment to GDP has increased gradually over time (1.2 per cent per annum over the period 1973-1990), the public sector investment to output ratio has been fairly volatile--increasing at a rate of 9.7 per cent during the 1970s and decreasing by 3 per cent per annum during the 1990s. As a result, the 1980s have seen a fairly dramatic fall in the ratio of public sector infrastructure to national income--output is being supported by less and less infrastructure.

TABLE 2

PAKISTAN: INFRASTRUCTURE AND DEVELOPMENT 1973-1990

A. Public Infrastructure Support For Private Investment 1973-1990

Average Annual Percentage Rates of Growth

	1973-90	1973-80	1980-90	1985-90
Share of Total				
Capital Formation				
Public Sector	1.3	5.5	-2.0	-2.0
Private Sector	-1.0	-5.0	2.4	2.2
Private Sector Share				
Total Public Infrastructure	-0.6	-5.3	3.3	5.8
Total Expected Infrastructure	-0.3	-5.3	3.8	3.3
Expected General Infrastructure	-1.5	-6.1	2.3	3.6
Expected Energy Infrastructure	-5.5	-6.8	-4.4	-9.8

B. Infrastructure and National Output 1973-1990

Average Annual Percentage Rates of Growth and *(Average Share)*

	1973-90	1973-80	1980-90	1985-90
Investment				
Total Investment 1.2	4.6	-1.1	0.6	
	(17.2)	*(17.6)*	*(17.1)*	*(17.0)*
Public Investment	2.0	9.7	-3.0	-1.3
	(9.6)	*(10.3)*	*(9.3)*	*(8.9)*
Private Investment	0.4	-0.7	1.2	2.7
	(7.5)	*(7.3)*	*(7.7)*	*(7.9)*
Infrastructure				
Actual	0.8	5.6	-2.4	-0.4
	(9.7)	*(10.3)*	*(9.4)*	*(8.8)*
Expected	0.0	2.6	-1.9	-2.8
	(9.6)	*(9.7)*	*(9.5)*	*(9.1)*

Source: Compiled from data in World Bank, *Pakistan: Current Economic Situation and Prospects--Report No. 9283-PAK* (March 22, 1991).

Notes: Expected infrastructure estimated from equation $INF_t = a + INF_{t-1}$ where INF_t is the investment in infrastructure in year t and INF_{t-1} is the investment in infrastructure in the previous year.

The patterns of infrastructure expansion, private sector investment and increased output of GDP are obviously complex. While the above patterns are consistent with a causal relationship whereby private sector investment is stimulated by infrastructure which in turn responds to increased output, they are by no means definitive. To sort out the causation issues, the following section examines Pakistan's macroeconomic linkages in a more formal manner.

The Impact of Infrastructure: The Issue of Causation

As noted, a major issue in the analysis of the role of infrastructure in Pakistan's post 1971 development centers on the direction of causation: does infrastructure affect various aspects of the national economy as suggested by Voigt or does it simply respond to the needs created by economic growth and investment?

Clearly, prior to drawing definitive conclusions concerning the impact of the government's large investment in infrastructure, one must satisfactorily address the issue of causation. Fortunately, several statistical tests using regression analysis for this purpose are gaining wider acceptance.

Granger Test

The original and most widely used causality test was developed by Granger.[18] According to this test, infrastructure causes (say) growth in GDP if growth can be predicted more accurately by past values of infrastructure investment than by past values of growth. To be certain that causality runs from infrastructure to growth, past values of energy must also be more accurate than past values of growth at predicting infrastructure expenditures.

More formally, Granger defines causality such that X Granger causes (G-C) Y if Y can be predicted more accurately in the sense of mean square error, with the use of past values of X than without using past X.[19] Based upon the definition of Granger causality, a simple bivariate autoregressive (AR) model for infrastructure (INF) and GDP can

be specified as follows:

$$(1) \quad GDP(t) = c + \sum_{i=1}^{p} a(i)GDP(t-i) + \sum_{j=1}^{q} b(j)INF(t-j) + u(t)$$

$$(2) \quad INF(t) = c + \sum_{i=1}^{r} d(i)INF(t-1) + \sum_{j=1}^{s} e(j)GDP(t-j) + v(t)$$

where GDP is the gross domestic product and INF = infrastructure expenditures; p, q, r and s are lag lengths for each variable in the equation; and u and v are serially uncorrelated white noise residuals. By assuming that error terms (u, v) are "nice," ordinary least squares (OLS) becomes the appropriate estimation method.[20]

Within the framework of unrestricted and restricted models, a joint F-test is appropriate for causal detection. Where:

$$3) \quad F = \frac{(RSS(x) - RSS(u)/(df(x) - df(u))}{RSS(u)/df(u) \text{and } RSS(r)}$$

and RSS(u) are the residual sum of squares of restricted and unrestricted models, respectively; and df(r) and df(u) are, respectively, the degrees of freedom in restricted and unrestricted models.

The Granger test detects causal directions in the following manner: first, unidirectional causality from INF to GDP if the F-test rejects the null hypothesis that past values of DEF in equation (1) are insignificantly different from zero and if the F-Test cannot reject the null hypothesis that past values of GDP in equation (2) are insignificantly different from zero. That is, DEF causes GDP but GDP does not cause INF. Unidirectional causality runs from GDP to DEF if the reverse is true. Second, bidirectional causality runs between DEF and GDP if both F-test statistics reiect the null hypotheses in equations (1) and (2). Finally, no causality exists between INF and GDP if we can not reject both null hypotheses at the conventional significance level.

The results of Granger causality tests depend critically on the choice of lag length. If the chosen lag length is less than the true lag length, the omission of relevant lags can cause bias. If the chosen lag is greater than the true lag length, the inclusion of irrelevant lags causes estimates to be inefficient. While it is possible to choose lag lengths based on preliminary partial autocorrelation methods, there is no a *priori* reason to assume lag lengths equal for all types of infrastructure.

The Hsiao Procedure

To overcome the difficulties noted above, Hsiao developed a systematic method for assigning lags.[21] This method combines Granger Causality and Akaike's final prediction error (FPE), the (asymptotic) mean square prediction error, to determine the optimum lag for each variable. In a paper examining the problems encountered in choosing lag lengths, Thornton and Batten found Hsiao's method to be superior to arbitrary lag length selection and to several other systematic procedures for determining lag length.[22]

The first step in Hsiao's procedure is to perform a series of autoregressive regressions on the dependent variable. In the first regression, the dependent variable has a lag of one. This increases by one in each succeeding regression. Here, we estimate M regressions of the form:

$$(4) \quad G(t) = a + \sum_{i=1}^{m} b(t-1)G(t-1) + e(i)$$

where the values of m range from 1 to M. For each regression, we compute the FPE in the following manner:

$$(5) \quad FPE(m) = \frac{T + m + 1}{T - m - 1} \quad ESS(m)/T$$

where T is the sample size, and FPE(m) and ESS(m) are the final prediction error and the sum of squared errors, respectively. The optimal lag length, m^*, is the lag length that produces the lowest FPE. Having determined m* additional regressions expand the equation with the lags on the other variable added sequentially in the same manner used to

determine m*. Thus we estimate four regressions of the form:

$$(6) \quad G(t) = a + \sum_{i=1}^{m^*} b(t-1)G(t-1) + \sum_{i=1}^{n} c(t-1)D(t-1) + e(i)$$

with n ranging from one to four. Computing the final prediction error for each regression as:

$$FPE(m^*,n) = \frac{T + m^* + n + 1}{T - m^* - n - 1} \, ESS(m^*,n)/T$$

we choose the optimal lag length for D, n* as the lag length that produces the lowest FPE. Using the final prediction error to determine lag length is equivalent to using a series of F tests with variable levels of significance.[23]

The first term measures the estimation error and the second term measures the modeling error. The FPE criterion has a certain optimality property that "balances the risk due to bias when a lower order is selected and the risk due to increases in the variance when a higher order is selected."[24] As noted by Judge et. al., an intuitive reason for using the FPE criterion is that longer lags increase the first term but decrease the RSS of the second term, and thus the two opposing forces optimally balanced when their product reaches its minimum.[25]

Depending on the value of the final prediction errors, four cases are possible: (a) *Infrastructure causes Growth* when the prediction error for growth decreases when infrastructure investment is included in the growth equation. In addition, when growth is added to the infrastructure equation, the final prediction error should increase; (b) *Growth causes Infrastructure* when the prediction error for growth increases when infrastructure is addeds to the regression equation for growth, and is reduced when growth is added to the regression equation for infrastructure; (c) *Feedback* occurs when the final prediction error decreases when defense is added to the growth equation, and the final prediction error decreases when growth is added to the defense infrastructure; and (d) *No Relationship* exists when the final prediction error increases both when defense is added to the growth equation and when growth is added to the infrastructure equation.

Operational Procedures

The data for investment and infrastructure expenditures used to carry out the causation tests were derived from World Bank, Pakistan: Current Economic Situation and Prospects--Report No. 10223-PAK (March 16, 1992); World Bank, Pakistan: Current Economic Situation and Prospects--Report No. 9283-PAK (March 22, 1991); and World Bank, Pakistan: Progress Under the Sixth Plan (1984). Both the Gross Domestic Product and the GDP price deflator are from various issues of the International Monetary Fund, International Financial Statistics Yearbook. All variables were deflated by the GDP deflator and are in constant 1985 prices. For best statistical results, the variables were transformed into their logarithmic values.[26]

To determine if the results were sensitive to the definition of infrastructure used, an additional measure of infrastructure, the *smoothed exponential trend* of the relevant form of public expenditure, was also introduced into the analysis. This second measure may be more stable than the expected (or anticipated) measure noted above. Because of this, the smoothed exponential trend is referred to as the *actual* increase in infrastructure in the results that follow.

As the analysis above indicates, the ratio of public to private investment has changed dramatically over time--relatively high in the 1970s and low in the 1980s. In part, this pattern stemmed from the relative stagnation of private investment in the 1970s due to political turmoil and uncertainty concerning nationalization. This pattern may bias our results to the extent that increased infrastructure in the 1970s may appear ineffective in stimulating private investment when in reality other factors offset its stimulus. To control for this potential bias, our measures of infrastructure were weighted by the ratio of public to private investment (referred to below as "weighted infrastructure").

Relationships between infrastructure expenditures and the economy were considered valid if they were statistically significant at the ninety-five per cent level of confidence. That is, if ninety-five per cent of the time we could conclude that they had not occurred by pure chance, we considered them statistically significant.

There is no theoretical reason to believe that infrastructure and the economy have a set lag relationship--that is, that they have an impact on one another over a fixed time period. The period could be a rather

short run involving largely the spin-off from construction or longer term as either term expands from the stimulus provided by the other. To find the optimal adjustment period of impact, lag structures of up to six years were estimated. The lag structure with the highest level of statistical significance was the one chosen to best depict the relationship under consideration (the optimal lag reported in Tables 3 through 5).

Results

The results for Gross Domestic Product (see Table 3 and 4) and private investment (see Table 5) indicate the direction of causation, together with the optimal lag time for each macro aggregate. As a basis of comparison, the results using public investment are also presented. Strength assessments reflect the magnitude of the impact and the statistical significance of the relationship.

TABLE 3

PAKISTAN: INTERACTION OF GENERAL PUBLIC INVESTMENT, INFRASTRUCTURE
AND GROSS DOMESTIC PRODUCT, 1972-1991

		Causation Patterns			Dominant Pattern
	A	B	C	D	
General Public Investment					
Optimal Lag (years)	1	3	1	2	
Final Prediction Error	(0.19E-3)	(0.19E-3)	(0.93E-2)	(0.54E-2)	
Durbin-Watson Statistic	3.38	2.91	1.57	1.83	Growth->
Ling-Box Q Statistic	11.01	13.15	5.22	13.86	Invest
Adjusted r^2	0.998	0.998	0.936	0.966	(+w)
General Public Infrastructure (anticipated)					
Optimal Lag (years)	1	2	1	2	
Final Prediction Error	(0.19E-3)	(0.18E-3)	(0.69E-2)	(0.38E-2)	
Durbin-Watson Statistic	2.38	3.04	1.69	1.86	Feedback
Ling-Box Q Statistic	11.01	15.37	4.99	20.83	(+w, +w)
Adjusted r^2	0.998	0.998	0.932	0.966	
General Weighted Public Infrastructure (anticipated)					
Optimal Lag (years)	1	2	1	2	
Final Prediction Error	(0.19E-3)	(0.20E-3)	(0.12E-1)	(0.11E-1)	
Durbin-Watson Statistic	2.38	3.01	1.82	1.70	Growth->
Ling-Box Q Statistic	11.01	18.14	5.53	11.19	Infrastructure
Adjusted r^2	0.998	0.998	0.786	0.810	(+w)
General Weighted Public Infrastructure (actual)					
Optimal Lag (years)	1	2	4	4	
Final Prediction Error	(0.19*E-3)	(0.20E-3)	(0.60E-2)	(0.39E-2)	
Durbin-Watson Statistic	2.38	3.08	2.11	1.90	Growth->
Ling-Box Q Statistic	11.01	19.74	4.18	18.14	Infrastructure
Adjusted r^2	0.998	0.998	0.368	0.660	(+m)

Notes: Summary of results obtained from Granger Causality Tests. A Hsiao Procedure was incorporated to determine the optimal lag. All variables estimated in logarithmic form. Anticipated infrastructure is the value predicted by regressing public investment on its value in the previous year. Actual infrastructure approximated as the smoothed exponential trend of public investment. **Regression Patterns: A** = growth on growth; **B** = investment (infrastructure) on growth; **C** = investment (infrastructure) on investment (infrastructure); and **D** = growth on investment (infrastructure). The Dominant pattern is that with the lowest final prediction error. Weighted = multiplied by the ratio of public to private infrastructure. The signs (+,-) represent the direction of impact. In the case of feedback the two signs represent the lowest final prediction error of relationships **B and D**. Each of the variables was regressed with 1, 2, 3, and 4 year lags. Strength assessment (s =strong; m = moderate; w = weak) based on the size of the standardized regression coefficient and t test of statistical significance.

TABLE 4

**PAKISTAN: INTERACTION OF PUBLIC ENERGY INVESTMENT,
INFRASTRUCTURE AND GROSS DOMESTIC PRODUCT, 1972-1991**

	Causation Patterns				Dominant Pattern
	A	B	C	D	
Public Energy Investment					
Optimal Lag (years)	1	2	4	1	
Final Prediction Error	(0.19E-3)	(0.19E-3)	(0.80E-1)	(0.62E-1)	
Durbin-Watson Statistic	3.38	3.01	2.37	2.67	Growth->
Ling-Box Q Statistic	11.01	13.26	1.66	4.67	Invest
Adjusted r^2	0.998	0.998	0.773	0.835	(+w)
Public Energy Infrastructure (anticipated)					
Optimal Lag (years)	1	1	4	1	
Final Prediction Error	(0.19E-3)	(0.21E-3)	(0.63E-1)	(0.55E-1)	
Durbin-Watson Statistic	2.38	2.40	2.55	2.76	Growth->
Ling-Box Q Statistic	11.01	8.94	2.45	4.58	Infrastructure
Adjusted r^2	0.998	0.998	0.752	0.795	(+w)
Public Energy Weighted Infrastructure (anticipated)					
Optimal Lag (years)	1	1	1	2	
Final Prediction Error	(0.19E-3)	(0.21E-3)	(0.81E-1)	(0.71E-1)	
Durbin-Watson Statistic	2.38	2.47	1.84	2.38	Growth->
Ling-Box Q Statistic	11.01	8.00	6.86	4.61	Infrastructure
Adjusted r^2	0.998	0.998	0.666	0.731	(+w)
Public Energy Infrastructure (actual)					
Optimal Lag (years)	1	2	4	1	
Final Prediction Error	(0.19E-3)	(0.16E-3)	(0.58E-2)	(0.34E-2)	
Durbin-Watson Statistic	2.38	3.35	2.61	2.89	Feedback
Ling-Box Q Statistic	11.01	18.78	7.19	19.08	(+w,+m)
Adjusted r^2	0.998	0.999	0.963	0.979	

Notes: Summary of results obtained from Granger Causality Tests. A Hsiao Procedure was incorporated to determine the optimal lag. All variables estimated in logarithmic form. Anticipated infrastructure is the value predicted by regressing public investment on its value in the previous year. Actual infrastructure approximated as the smoothed exponential trend of public investment. **Regression Patterns: A** = growth on growth; **B** = investment (infrastructure) on growth; **C** = investment (infrastructure) on investment (infrastructure); and **D** = growth on investment (infrastructure). The Dominant pattern is that with the lowest final prediction error. The signs (+,-) represent the direction of impact. In the case of feedback the two signs represent the lowest final prediction error of relationships B **and D**. Weighted = *multiplied by the ratio of public to private infrastructure. Each of the variables was regressed with 1, 2, 3, and 4 year lags. Strength assessment (s =strong; m = moderate; w = weak) based on the size of the standardized regression coefficient and t test of statistical significance.

Several important patterns characterize general government investment and infrastructure. (See Table 3). First, general public investment and infrastructure (composed of federal, provincial and local jurisdictions) tended to be determined by the overall expansion of the economy, rather than providing an initial stimulus to growth. The one exception is anticipated infrastructure where growth stimulated the provision of additional infrastructure and that infrastructure in turn contributed to further economic expansion. It should be noted, however, that both impacts were rather weak. Second, the pattern of public to private investment did not affect the overall conclusion that general public investment tends to be responsive to rather than initiating growth. Finally, the best results (in terms of the final prediction error) were obtained for our measure of actual infrastructure. This pattern continued throughout the analysis.

Similar patterns were obtained for the relationship between the expansion of the public sector in energy and overall economic growth. (See Table 4). Again, the overall picture is one whereby economic growth places pressure on the public sector to provide expanded amounts of energy. Only in the case of actual infrastructure was there any hint that expanded public sector infrastructure in energy stimulated the economy. Even here, the impact of overall growth on energy was much stronger than that from energy to growth.

To assess the effect of infrastructure on private investment, general public investment was examined in terms of its components. Logically, each source of public funds (federal, provincial and local) might be biased towards the provision of one type of infrastructure--federal towards communications, provincial towards transportation, and local authorities concerned more with filling the remaining gaps.

Again, the data reveal several patterns. (See Table 5). First, while federal investment provided a weak stimulus to private investment (and in turn was affected by private investment) the dominant pattern is for federal infrastructure either to impact negatively on private investment or to respond to the needs created by expanded private sector investment. Second, as with federal investment, provincial investment has provided a

TABLE 5

PAKISTAN: INTERACTION OF GENERAL PUBLIC INVESTMENT,
INFRASTRUCTURE AND PRIVATE SECTOR INVESTMENT, 1972-1991

	Causation Patterns				Dominant Pattern
	A	B	C	D	
Federal Investment					
Optimal Lag (years)	3	3	1	3	
Final Prediction Error	(0.17E-2)	(0.16E-2)	(0.17E-1)	(0.12E-1)	
Durbin-Watson Statistic	2.49	2.33	2.47	1.67	Feedback
Ling-Box Q Statistic	9.86	9.75	10.76	7.52	(+w, +w)
Adjusted r^2	0.990	0.992	0.864	0.843	
Federal Infrastructure (anticipated)					
Optimal Lag (years)	3	4	1	4	
Final Prediction Error	(0.17E-2)	(0.11E-2)	(0.11E-1)	(0.60E-2)	
Durbin-Watson Statistic	2.49	2.08	2.51	2.10	Feedback
Ling-Box Q Statistic	9.86	6.47	10.86	13.29	(-w, +w)
Adjusted r^2	0.990	0.994	0.838	0.875	
Federal Weighted Infrastructure (anticipated)					
Optimal Lag (years)	3	4	1	4	
Final Prediction Error	(0.17E-2)	(0.18E-2)	(0.16E-1)	(0.12E-1)	
Durbin-Watson Statistic	2.49	1.83	2.09	1.40	Investment->
Ling-Box Q Statistic	9.86	4.72	6.30	9.88	Infrastructure
Adjusted r^2	0.990	0.990	0.658	0.272	(+w)
Federal Infrastructure (actual)					
Optimal Lag (years)	3	1	2	4	
Final Prediction Error	(0.17E-2)	(0.20E-2)	(0.86E-2)	(0.43E-2)	
Durbin-Watson Statistic	2.38	2.40	2.11	1.66	Investment->
Ling-Box Q Statistic	11.01	8.52	3.21	5.28	Infrastructure
Adjusted r^2	0.998	0.99	0.916	0.731	(+w)
Provincial Government Investment					
Optimal Lag (years)	3	1	2	1	
Final Prediction Error	(0.17E-2)	(0.17E-2)	(0.13E-1)	(0.99E-2)	
Durbin-Watson Statistic	2.49	2.30	1.31	2.70	Feedback
Ling-Box Q Statistic	9.86	7.26	6.06	4.81	(-w, +w)
Adjusted r^2	0.990	0.990	0.902	0.928	

TABLE 5 (CONTINUED)
PAKISTAN: INTERACTION OF GENERAL PUBLIC INVESTMENT,
INFRASTRUCTURE AND PRIVATE SECTOR INVESTMENT, 1972-1991

	Causation Patterns				Dominant Pattern
	A	B	C	D	
Provincial Government Infrastructure (anticipated)					
Optimal Lag (years)	3	4	2	4	
Final Prediction Error	(0.17E-2)	(0.14E-2)	(0.98E-2)	(0.80E-2)	
Durbin-Watson Statistic	2.49	2.15	2.22	2.82	Feedback
Ling-Box Q Statistic	9.86	9.46	5.26	7.21	(-w, +w)
Adjusted r^2	0.990	0.992	0.892	0.919	
Provincial Government Infrastructure (actual)					
Optimal Lag (years)	3	2	4	2	
Final Prediction Error	(0.17E-2)	(0.16E-2)	(0.73E-3)	(0.40E-3)	
Durbin-Watson Statistic	2.49	2.79	2.19	2.50	Feedback
Ling-Box Q Statistic	9.86	7.72	4.57	6.05	(-w, +w)
Adjusted r^2	0.990	0.987	0.989	0.994	
Provincial Government Weighted Infrastructure (actual)					
Optimal Lag (years)	3	2	4	2	
Final Prediction Error	(0.17E-2)	(0.15E-2)	(0.67E-2)	(0.48E-2)	
Durbin-Watson Statistic	2.38	2.41	2.01	1.53	Feedback
Ling-Box Q Statistic	11.01	9.07	3.75	8.87	(-w, +w)
Adjusted r^2	0.990	0.992	0.381	0.584	
Local Government Investment					
Optimal Lag (years)	3	1	4	1	Final
Prediction Error	(0.17E-2)	(0.16E-2)	(0.30E-1)	(0.25E-2)	
Durbin-Watson Statistic	2.49	2.79	1.97	2.09	Feedback
Ling-Box Q Statistic	9.86	11.23	9.71	9.61	(-w, +w)
Adjusted r^2	0.990	0.991	0.870	0.898	
Local Government Infrastructure (anticipated)					
Optimal Lag (years)	3	2	1	1	
Final Prediction Error	(0.17E-2)	(0.18E-2)	(0.32E-1)	(0.22E-1)	
urbin-Watson Statistic	2.49	2.63	1.75	1.47	Private->
ing-Box Q Statistic	9.86	11.19	13.32	21.48	Infrastructure
Adjusted r^2	0.990	0.990	0.852	0.901	(+m)

TABLE 5 (CONTINUED)
PAKISTAN: INTERACTION OF GENERAL PUBLIC INVESTMENT,
INFRASTRUCTURE AND PRIVATE SECTOR INVESTMENT, 1972-1991

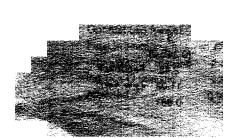|	Causation Patterns				Dominant Pattern
	A	B	C	D	
Local Government Infrastructure (actual)					
Optimal Lag (years)	3	2	4	2	
Final Prediction Error	(0.17E-2)	(0.16E-2)	(0.73E-2)	(0.40E-2)	
Durbin-Watson Statistic	2.49	2.71	1.73	2.18	Feedback
Ling-Box Q Statistic	9.86	9.82	6.17	4.18	(-w.+w)
Adjusted r^2	0.990	0.981	0.987	0.989	
Local Government Weighted Infrastructure (actual)					
Optimal Lag (years)	3	2	3	4	
Final Prediction Error	(0.17E-2)	(0.16E-2)	(0.25E-2)	(0.21E-2)	
Durbin-Watson Statistic	2.38	2.71	2.15	1.75	Feedback
Ling-Box Q Statistic	11.01	9.83	7.58	9.98	(-w.+w)
Adjusted r^2	0.990	0.991	0.988	0.991	
Public Energy Investment					
Optimal Lag (years)	3	2	4	1	
Final Prediction Error	(0.17E-2)	(0.15E-2)	(0.81E-1)	(0.66E-2)	
Durbin-Watson Statistic	2.49	2.79	2.37	2.64	Feedback
Ling-Box Q Statistic	9.86	9.91	1.66	4.18	(+w.+w)
Adjusted r^2	0.990	0.992	0.772	0.824	
Public Energy Infrastructure (anticipated)					
Optimal Lag (years)	3	2	1	4	
Final Prediction Error	(0.17E-2)	(0.11E-2)	(0.81E-1)	(0.64E-1)	
Durbin-Watson Statistic	2.49	2.08	1.83	2.29	Feedback
Ling-Box Q Statistic	9.86	6.34	6.86	13.45	(+w.+w)
Adjusted r^2	0.990	0.992	0.666	0.536	
Public Energy Infrastructure (actual)					
Optimal Lag (years)	3	4	4	3	
Final Prediction Error	(0.17E-2)	(0.14E-2)	(0.58E-2)	(0.34E-2)	
Durbin-Watson Statistic	2.49	2.04 *	2.61	2.48	Feedback
Ling-Box Q Statistic	9.86	3.19	7.18	11.02	(+w,+w)
Adjusted r^2	0.990	0.992	0.962	0.981	

TABLE 5 (CONTINUED)
PAKISTAN: INTERACTION OF GENERAL PUBLIC INVESTMENT,
INFRASTRUCTURE AND PRIVATE SECTOR INVESTMENT, 1972-1991

	Causation Patterns				Dominant Pattern
	A	B	C	D	
Public Energy Weighted Infrastructure (actual)					
Optimal Lag (years)	3	1	2	1	
Final Prediction Error	(0.17E-2)	(0.14E-2)	(0.14E-1)	(0.11E-1)	
Durbin-Watson Statistic	2.38	2.59	1.96	2.76	Feedback
Ling-Box Q Statistic	11.01	9.69	8.85	15.12	(+w,+w)
Adjusted r^2	0.990	0.992	0.941	0.952	

Notes: Summary of results obtained from Granger Causality Tests. A Hsiao Procedure was incorporated to determine the optimal lag. All variables estimated in logarithmic form. Anticipated infrastructure is the value predicted by regressing public investment on its value in the previous year. Actual infrastructure approximated as the smoothed exponential trend of public investment. **Regression Patterns: A** = private investment on private investment; **B** = public investment (infrastructure) on private investment; **C** = investment (infrastructure) on investment (infrastructure); and **D** = private investment on public investment (infrastructure). The Dominant pattern is that with the lowest final prediction error. The signs (+,-) represent the direction of impact. In the case of feedback the two signs represent the lowest final prediction error of relationships **B and D**. Weighted = multiplied by the ratio of public to private infrastructure. Each of the variables was regressed with 1, 2, 3, and 4 year lags. Strength assessment (s =strong: m = moderate; w = weak) based on the size of the standardized regression coefficient and t test of statistical significance.

stimulus to private investment (and in turn responded positively to increased private investment). In contrast, provincial government infrastructure is more interdependent than private investment. Again, however, the impact of provincial infrastructure on private investment has been largely negative. Third, local government investment has had a weak negative impact on private investment. On the other hand, local infrastructure has followed a pattern similar to that of provincial infrastructure: negative interdependency with private investment. Finally, the bright spot in the public sector's program appears to be in the area of energy. Here, all forms of energy investment and infrastructure (with the exception of weighted infrastructure) provided a mild stimulus to private investment.

Although beyond the scope of this article to investigate, a possible explanation for the apparent negative relationship between public infrastructure and private investment may lie in the manner in which the public sector finances these projects. A recent study Burney and Yasmeen suggests that when infrastructure projects are financed through borrowing from the banking system, higher nominal interest rates may ensue.[27] They argue that "These in turn may end up crowding out private investment and consumption expenditures. Thus the government's efforts to boost investment in the economy by increasing the share of the public sector, particularly by borrowing, is likely to fall short of its objectives. This may also lead to a slowing down of the economy."[28]
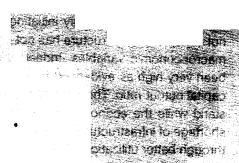
Conclusions

The main finding of the analysis presented above is that infrastructure in Pakistan has acted rather passively in the sense that it has responded to the needs of the overall economy and the private sector, rather than strongly initiating growth in either of them. This does not mean that infrastructure has not contributed to the expansion of these macroeconomic variables. Indeed the productivity of infrastructure has been very high as evidenced by the country's extremely low incremental capital output ratio. The country has not built infrastructure only to have it stand while the economy grows into it. On the other hand, the relative shortage of infrastructure means the economy has little room to maneuver through better utilization of existing facilities.

Of particular importance to the present study is the fact that the investment rate in Pakistan is unusually low relative to historical GDP growth rates. Over the last decade the incremental capital output ratio (ICOR) was 2.7. This low ratio probably resulted from the factors noted above, and from the fact that over the past decade Pakistan has been depleting its existing capital stock by neglecting maintenance and replacement investment. It has also been making only low levels of investments in social sectors. Thus it is likely that the ICORs will be higher in the future because of heavy infrastructure investment requirements, especially for energy, highways, and basic amenities in urban and rural areas. Therefore, maintaining the historical GDP growth rate of 6 per cent per annum will require a substantial increase in the rate of investment.[29]

Clearly a number of factors will affect Pakistan's growth over the next several years, and lack of infrastructure is only one of them. In the case of manufacturing a pattern is already becoming apparent. In 1990 growth in large scale manufacturing was only about half the average rate for the period 1978-1988. The factors responsible for the recent poor performance are both internal and external. In addition to infrastructure bottlenecks, internal factors include political uncertainty and production disruptions arising from the deterioration in public order. External factors having an adverse impact on growth in manufacturing arise from the inefficient, inward oriented and highly protected nature of industry.

Overall, the findings presented in this paper suggest that the infrastructure bottleneck may become pervasive across a number of key sectors and, perhaps in the next several years, overshadow other factors currently restraining output.

NOTES

1. *Asian Development Outlook, 1991* (Manila: Asian Development Bank, 1991), p. 157.

2. Habib A. Zuberi, "Economic Development in Pakistan," *Journal of South Asian and Middle Eastern Studies* (Summer 1990), p. 44.

3. Mario I. Blejer and Mohsin S. Khan, "Public Investment and Crowding Out in The Caribbean Basin Countries," in Michael Connolly and John McDermott, *The Economics of the Caribbean Basin* (New York: Praeger Publishers, 1985), pp. 219-236.

4. Calculated from data in World Bank, *Pakistan: Current Economic Situation and Prospects--Report No. 9283-PAK* (March 22, 1991); and World Bank, *Pakistan: Progress Under the Sixth Plan* (1984).

5. *Ibid.*

6. A.O. Hirschman, *The Strategy of Economic Development* (New Haven: Yale University Press, 1958).

7. Based on G. Wolfgang Heinze, "Toward a Theory of Transport and Regional Development: A Critical Appraisal of Voigt's Theory," *Rivista Internazionale di Economia dei Transporti* (April 1976), pp. 5-7.

8. See his "Tasks of Modern Transport Science," *Rivista Internazionale di Economia Dei Transporti* (1974), pp. 255-262.

9. A.O. Hirschman, *The Strategy of Economic Development* (New Haven: Yale University Press, 1958).

10. See for example Neils Hansen, "Unbalanced Growth and Regional Development," *Western Economic Journal* (1965), pp. 3-14.

11. G. Kraft, J. Meyer and A. Valette, *The Role of Transportation in Regional Economic Development* (Lexington, Mass: Lexington Books, 1971).

12. Hans Alder, "Economic Evaluation of Transportation Projects," in G. Fromm ed., *Transport Investment and Economic Development* (Washington: The Brooking Institution, 1965), p. 189.

13. Donald Glover and Julian Simon, "The Effect of Population Density of Infrastructure: The Case of Road Building," *Economic Development and Cultural Change* (April 1975), pp. 453-68.

14. Julian Simon, "The Positive Effect of Population Growth on Agricultural Saving in Irrigation Systems," *Review of Economics and Statistics* (February 1975), pp. 71-79.

15 Peter C. Frederiksen "Further Evidence on the Relationship between Population Density and Infrastructure: The Philippines and Electrification," *Economic Development and Cultural Change* (July 1981), pp. 749-758.

16. Calculated from data in World Bank, *Pakistan: Current Economic Situation and Prospects--Report No. 9283-PAK* (March 22, 1991).

17.   *Ibid.*

18.   C.W.J. Granger, "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," *Econometrica* (1969), pp. 424-438.

19.   *Ibid.*

20.   If the disturbances of the model were serially correlated, the OLS estimates would be inefficient, although still unbiased, and would distort the causal relations. The existence of serial correlation was checked by using a maximum likelihood correlation for the first-order autocorrelation of the residuals [AR(1)]. The comparison of both OLS and AR(1) results indicated that no significant changes appeared in causal directions. Therefore, we can conclude 'roughly' that serial correlation was not serious in this model.

21.   C. Hsiao, "Autoregressive Modeling and Money-Income Causality Detection," *Journal of Monetary Economics* (1081), pp. 85-106.

22.   D.L. Thornton and D.S. Batten, "Lag-length Selection and Tests of Granger Causality Between Money and Income," *Journal of Money, Credit and Banking* (1985), pp. 164-78.

23.   Since the F statistics are redundant in this instance they are not reported here. They are, however, available from the authors upon request.

24.   C. Hsiao, "Causality Tests in Econometrics," *Journal of Economic Dynamicsnd Control* (1979), p.326.

25.   G.G. Judge, W. Hill, H. Griffiths, H. Lutkephol, and T.C. Lee, *Introduction to the Theory and Practice of Econometrics* (New York: John Wiley and Sons, 1982).

26.   The underlying reasons involve the assumption of stationary conditions. See C. Hsiao, "Autoregressive Modeling and Money-Income Causality Detection, " *Journal of Monetary Economics* (1981), pp. 85-106 and W. Joerding, "Economic Growth and Defense Spending: Granger Causality," *Journal of Development Economics* (1986), pp. 35-40.

27.   Nadeem A. Burney and Attiya Yasmeen, "Government Budget Deficits and Interest Rates: an Empirical Analysis for Pakistan," *The Pakistan Development Review* (Winter 1989), vol. 28, no. 4 Part II, pp. 971-980.

28.   *Ibid.* p. 978.

29.   *Asian Development Look*, 1989 (Manila, The Asian Development Bank, 1989), p. 132. Endnotes